methyl ethyl ketone, and isobutyl methyl ketone; alcohols such as n-butanol, and ethanol; paraffin oils; ethers such as tetrahydrofuran and dioxane; dimethylformamide, and dimethyl sulfoxide.

In a preferred embodiment a portion or all of the solvent is selected from the group consisting of methyl ethyl ketone, isobutyl methyl ketone, anisole, n-butanol, dimethylformamide, dimethyl sulfoxide, benzene, petroleum ether, acetone, hexane, ethanol, ortho-xylene, and mixtures thereof. Preferably, the solvent has a high solubility for the monomers and a high boiling point. In a particularly preferred embodiment a portion or all of the solvent is selected from the group consisting of methyl ethyl ketone, isobutyl methyl ketone, anisole, dimethylformamide, dimethyl sulfoxide, and mixtures thereof. In an even more preferred embodiment the solvent is methyl isobutyl ketone. Preferably, the portion of the solvent selected from the abovementioned groups is at least 50 wt-% based on the total amount of solvent, more preferably at least 80 wt-%, even more preferably 100 wt-%.

Preferably, the solvent or solvent mixture is the same for the initial reaction solution, and the first feed solution.

The copolymers prepared by the present method have a number average molecular weight of 3000 to 9000 g/mol and a polydispersity index (defined as the ratio of the weight average to the number average molecular weight) of preferably up to 5. The number average molecular weight and the weight average molecular weight can be determined by gel permeation chromatography (GPC) against poly(methyl methacrylate) standards. A mixture of 0.2 wt-% trifluoroacetic acid in tetrahydrofuran (THF) is used as eluent.

In a second aspect, the present invention relates to a copolymer comprising one or more alkyl methacrylate monomer units and maleic anhydride monomer units, which is obtained by the process as described above and is characterized in that the number average molecular weight of the copolymer is in the range of 3000 to 9000 g/mol, wherein the number average molecular weight is determined by gel permeation chromatography against poly(methyl methacrylate) standards. The copolymers of the present invention have a polydispersity index in the range of 1 to 5, preferably in the range of 3 to 5, which is determined by gel permeation chromatography against poly(methyl methacrylate) standards. Other well-known GPC standards such as poly(styrene) can also be used.

The alkyl methacrylate monomer units comprised in the copolymers of the present invention are preferably derived from the group of alkyl methacrylates mentioned above. In a particularly preferred embodiment, the alkyl methacrylate monomer units are derived from the group consisting of linear C_6 methacrylate, linear C_8 methacrylate, linear C_{10} methacrylate, branched C_{10} alkyl

Claims

1. A method for the preparation of a sulfur-free copolymer comprising alkyl methacrylate monomer units and maleic anhydride monomer units by solution polymerization of one or more alkyl methacrylates and maleic anhydride in a solvent in the presence of a radical initiator, said method comprising the steps of

   a) providing an initial reaction solution comprising a portion of the one or more alkyl methacrylates, a portion of the maleic anhydride, a portion of the initiator and a portion of the solvent;

   b) adding a first feed solution comprising a further portion of the maleic anhydride and a further portion of the solvent to the initial reaction solution, and without any initiator; and

   c) adding a second feed solution comprising a further portion of the one or more alkyl methacrylates, and a portion of the radical initiator to the initial reaction solution,

   wherein the additions of both first and second feed solutions are started at the same time, and the duration of the additions of the first and second feed solutions are adjusted such that addition of the first feed solution is completed faster than the addition of the second feed solution, and

   wherein the sulfur-free copolymer has a number average molecular weight of 3000 to 9000 g/mol, being the number average molecular weight determined by gel permeation chromatography against poly(methyl methacrylate) standards, and a polydispersity index in the range of 1 to 5, being the polydispersity index determined by gel permeation chromatography against poly(methyl methacrylate) standards, and

   wherein the molar ratio of the one or more alkyl methacrylates to the maleic anhydride in the sulfur-free copolymer is in the range of from 10:1 to 1:1, based on the total molar amounts of the one or more alkyl methacrylates and maleic anhydride used for the preparation of the sulfur-free copolymer.

2. The method according to claim 1, wherein the first and second feed solutions are added over the course of 30 minutes to 12 hours.

3. The method according to claim 1 or 2, wherein the first feed solution is added to the initial reaction solution over the course of 2 to 4 hours and the second feed solution is added to the initial solution over the course of 5 to 7 hours.

4. The method according to any one of the preceding claims, wherein the first feed solution is added to the initial reaction solution over the course of 2.5 to 3.5 hours and the second feed solution is added to the initial solution over the course of 5.5 to 6.5 hours.

5. The method according to any one of the preceding claims, wherein the portion of the one or more alkyl methacrylates in the initial reaction solution is 5 to 25 wt-% based on the total amount of the one or more alkyl methacrylates.

6. The method according to any one of the preceding claims, wherein the portion of the one or more alkyl methacrylates in the second feed solution is 75 to 95 wt-% based on the total amount of the one or more alkyl methacrylates.

7. The method according to any one of the preceding claims, wherein the sum of the portions of the one or more alkyl methacrylates in the initial reaction solution and in the second feed solution is 50 to 100 wt-% based on the total amount of the one or more alkyl methacrylates.

8. The method according to any one of the preceding claims, wherein the portion of the maleic anhydride in the initial reaction solution is 5 to 25 wt-% maleic anhydride based on the total amount of maleic anhydride.

9. The method according to any one of the preceding claims, wherein the portion of the maleic anhydride in the first feed solution is 75 to 95 wt-% maleic anhydride based on the total amount of maleic anhydride.

10. The method according to any one of the preceding claims, wherein the sum of the portions of the maleic anhydride in the initial reaction solution and in the first feed solution is 50 to 100 wt-% based on the total amount of the maleic anhydride.

11. The method according to any one of the preceding claims, wherein the total amount of the one or more alkyl methacrylates and the maleic anhydride is in the range of 10 to 60 wt.-% relative to the total weight of the sum of the initial reaction solution and the first feed solution and the second feed solution.

12. The method according to any one of the preceding claims, wherein at least 80 mol-% of the one or more alkyl methacrylates is selected from the group of C_6 to C_{22} alkyl methacrylates, or a mixture thereof.

13. The method according to any one of the preceding claims, wherein a portion or all of the solvent is selected from the group consisting of methyl ethyl ketone, isobutyl methyl ketone, anisole, n-butanol, dimethylformamide, dimethyl sulfoxide, benzene, petroleum ether, acetone, hexane, ethanol, ortho-xylene, and mixtures thereof.

14. The method according to any one of the preceding claims, comprising the step of

d) adding a final portion of the initiator after addition of the feed solutions has been completed.

15. The method according to any one of the preceding claims, wherein each of the initial reaction solution, the second feed solution, and the final initiator dosage comprise at least 0.05 wt-% initiator based on the total amount of monomers.

16. A sulfur-free copolymer obtained by the method as defined in any one of claims 1 to 15, wherein the number average molecular weight of the copolymer is in the range of 3000 to 9000 g/mol, wherein the number average molecular weight is determined by gel permeation chromatography against poly(methyl methacrylate) standards, and the polydispersity index of the copolymer is in the range of 1 to 5, wherein the polydispersity index is determined by gel permeation chromatography against poly(methyl methacrylate) standards, and the molar ratio of the one or more alkyl methacrylates to the maleic anhydride in the resulting copolymer is in the range of from 10:1 to 1:1, based on the total molar amounts of the one or more alkyl methacrylates and maleic anhydride used for the preparation of the sulfur-free copolymer.

17. The sulfur-free copolymer according to claim 16, wherein the sulfur-free copolymer comprises equimolar amounts of the one or more alkyl methacrylates and maleic anhydride, based on the total molar amounts of the one or more alkyl methacrylates and maleic anhydride used for the preparation of the sulfur-free copolymer.